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A GENERIC EFFICIENT ADAPTIVE GRID SCHEME FOR ROCKET PROPULSION MODELING

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Abstract

The objective of this research is to develop an efficient, time-accurate numerical algorithm to discretize the Navier-Stokes equations for the predictions of internal one-, two-dimensional and axisymmetric flows. A generic, efficient, elliptic adaptive grid generator is implicitly coupled with the Lower-Upper factorization scheme in the development of ALUNS computer code. The calculations of one-dimensional shock tube wave propagation and two-dimensional shock wave capture, wave-wave interactions, shock wave-boundary interactions show that the developed scheme is stable, accurate and extremely robust. The adaptive grid generator produced a very favorable grid network by a grid speed technique. This generic adaptive grid generator is also applied in the PARC and FDNS codes and the computational results for solid rocket nozzle flowfield and crystal growth modeling by those codes will be presented in the conference, too. This research work is being supported by NASA/MSFC.

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MOTIVATION

* Time-dependent sharp gradient region
  -shock wave propagation
  -shedding vortex
* Moving boundary
  -time-dependent geometrical boundary
  (solid rocket chamber, etc.)
  -time-dependent free surface
* Unknown sharp region for steady solution
  -shock capture
  -boundary layer

OBJECTIVES

* To develop an adaptive grid generator
  -efficient
  -robust
  -easy to be embodied in computer codes
  -numerically stable with most schemes

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Elliptic PDEs for Grid Generation

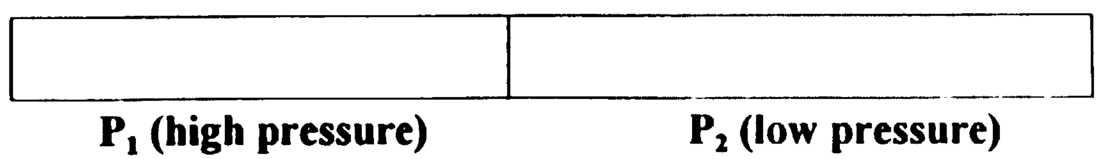
$$\zeta_{xx} + \zeta_{yy} = P$$

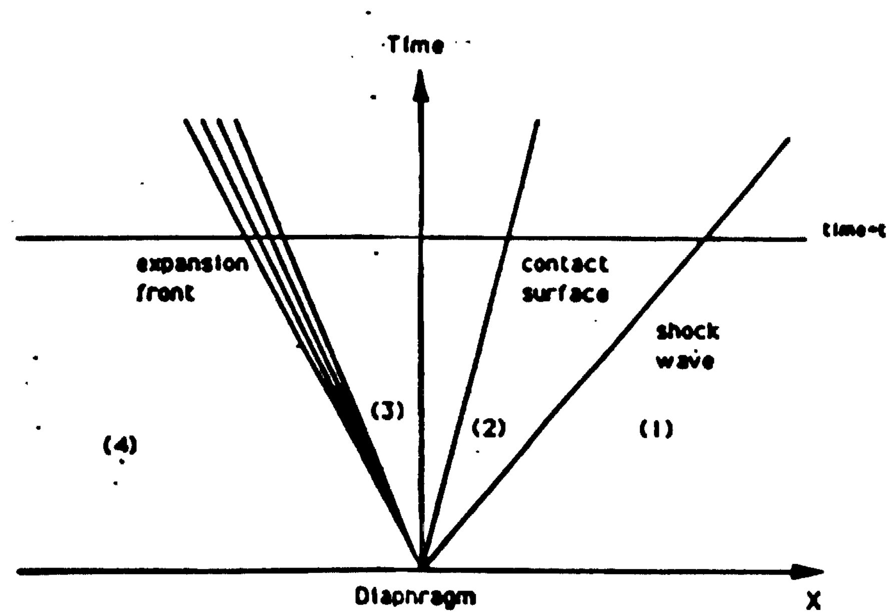
$$\eta_{xx} + \eta_{yy} = Q$$

where P and Q are the control functions, and they could be

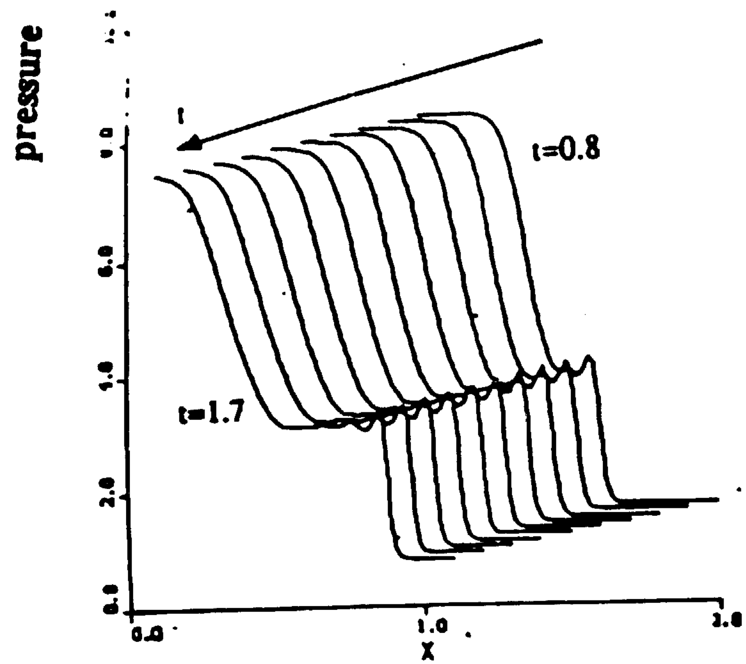
$$P = P_g + P_w + \ldots\ldots$$
$$Q = Q_g + Q_w + \ldots\ldots$$

CASE 1. SHOCK TUBE

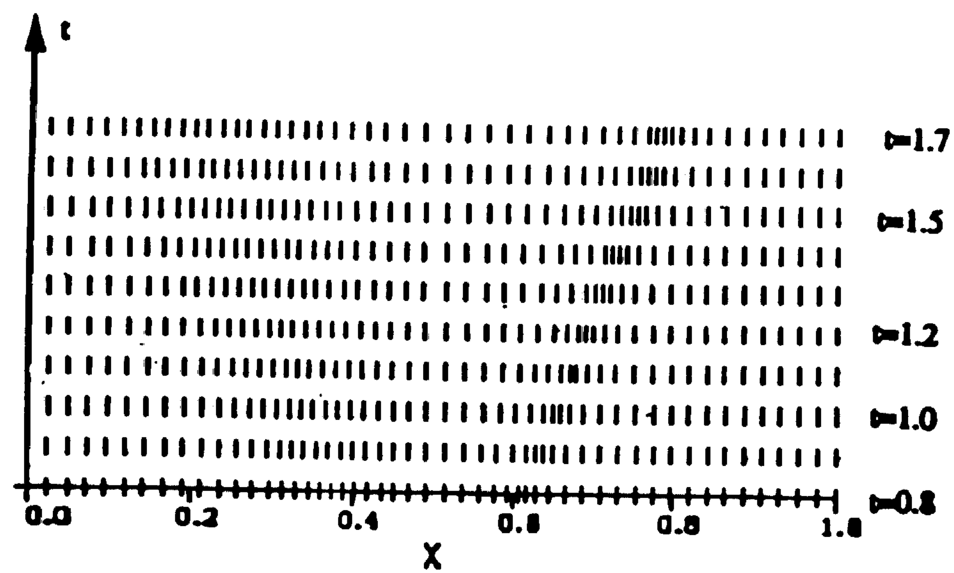




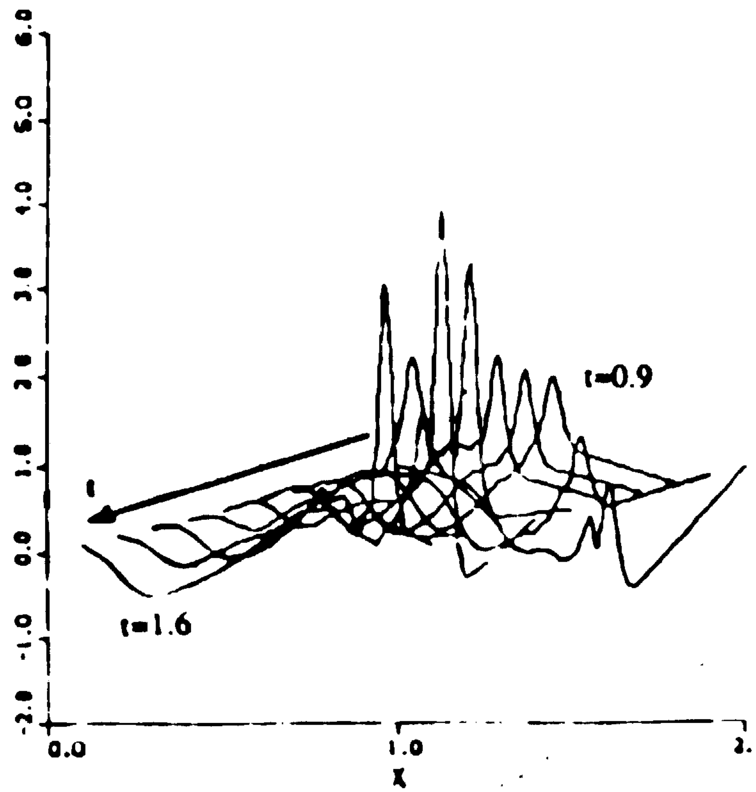
Schematic of shock tube solution



Shock tube pressure solution

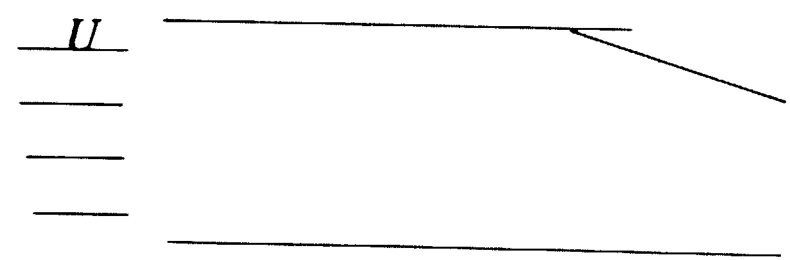


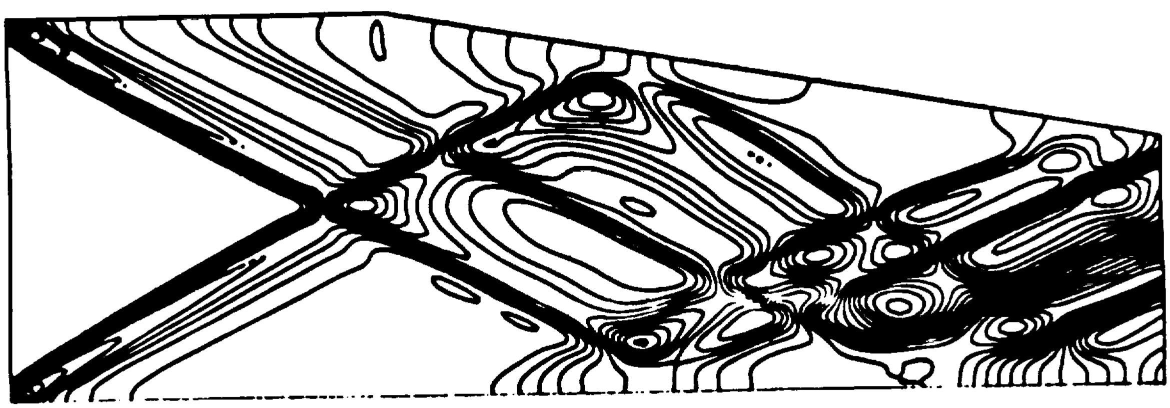
Time-accurate adaptive grid in one-dimensional shock tube simulation



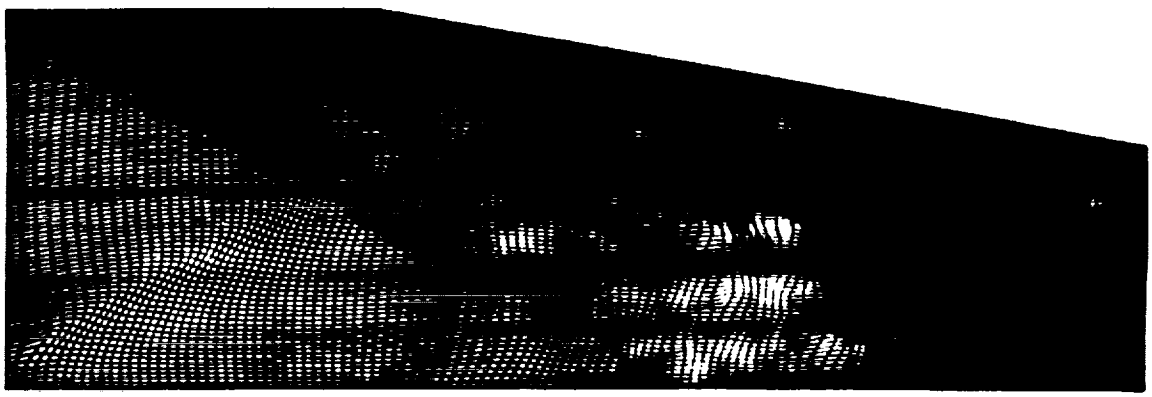
Adaptive grid speed in shock tube solution

CASE 2. SUPERSONIC RAMP INLET



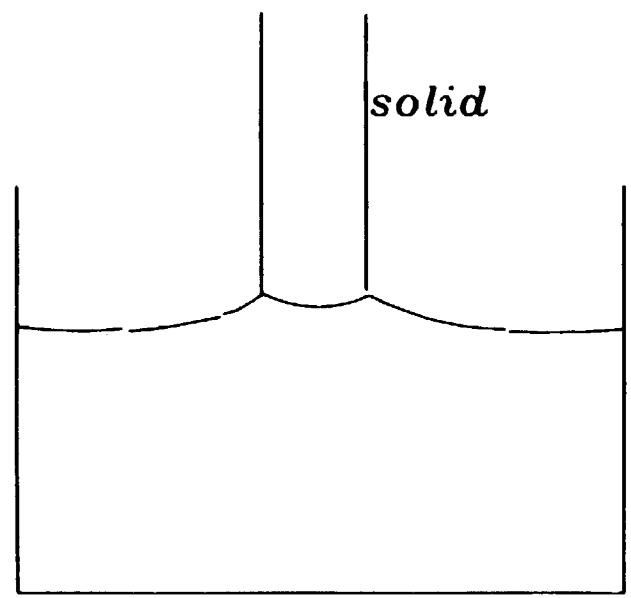


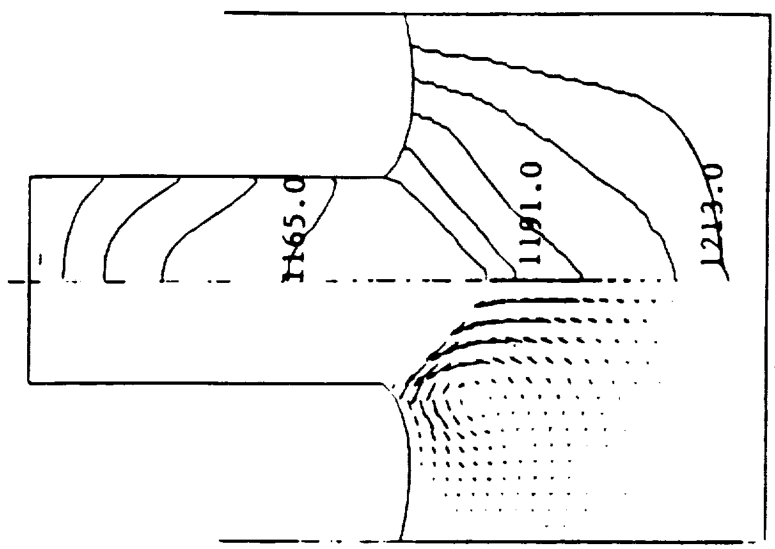
Pressure contour plot inside a two-dimensional duct.



Adapted grid of a two-dimensional duct.

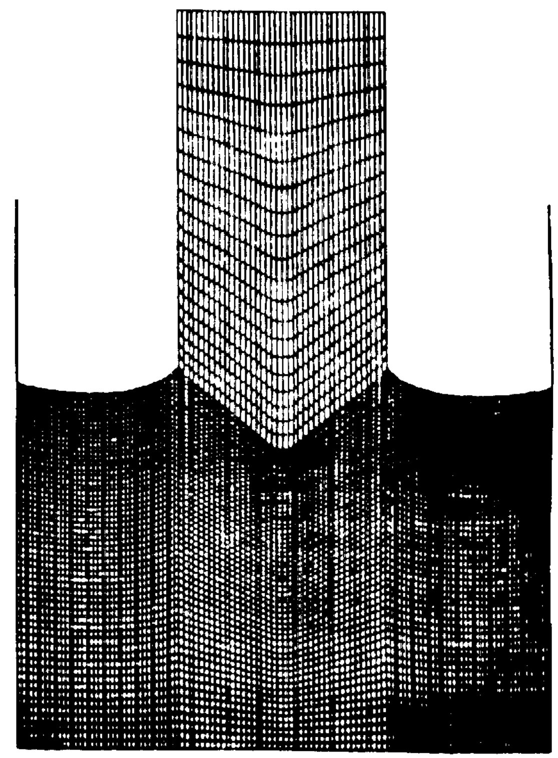
CASE 3. CAVITY FLOW SIMULATION





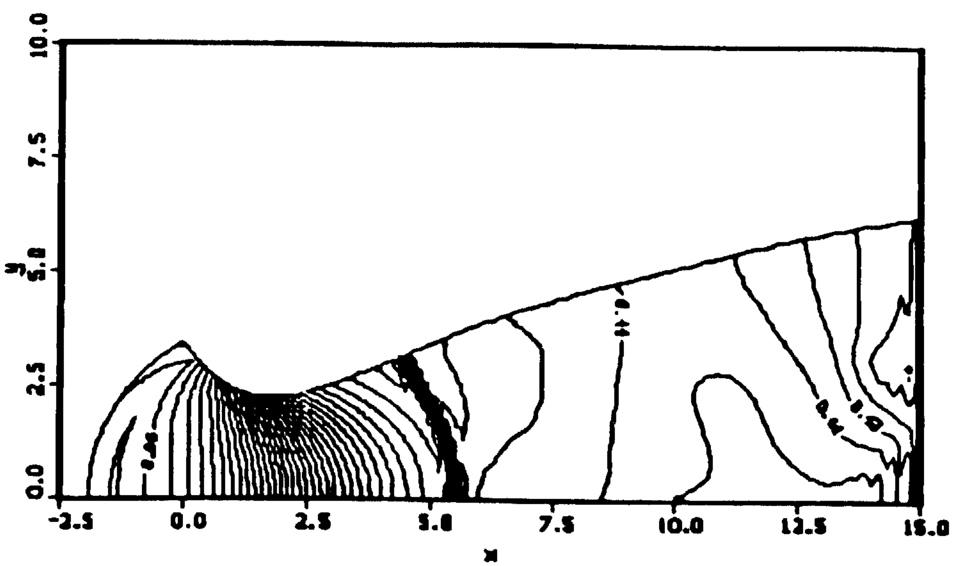
Flow field and isotherms

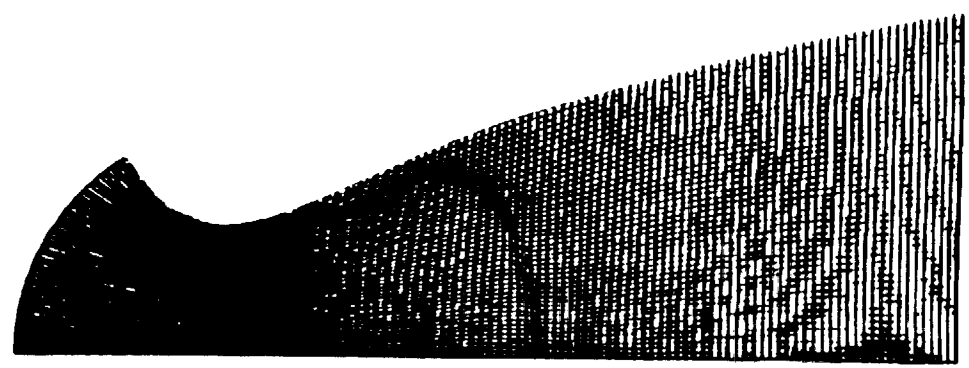
C-3.



Computational grids

CASE 4. SOLID ROCKET NOZZLE FLOW MODELING





(b) An adapted grid

CONCLUSIONS

- Versatile grid generator
- Robust to general schemes (LU,FDNS,PARC)
- Efficient and compact